SURVEY NOTES

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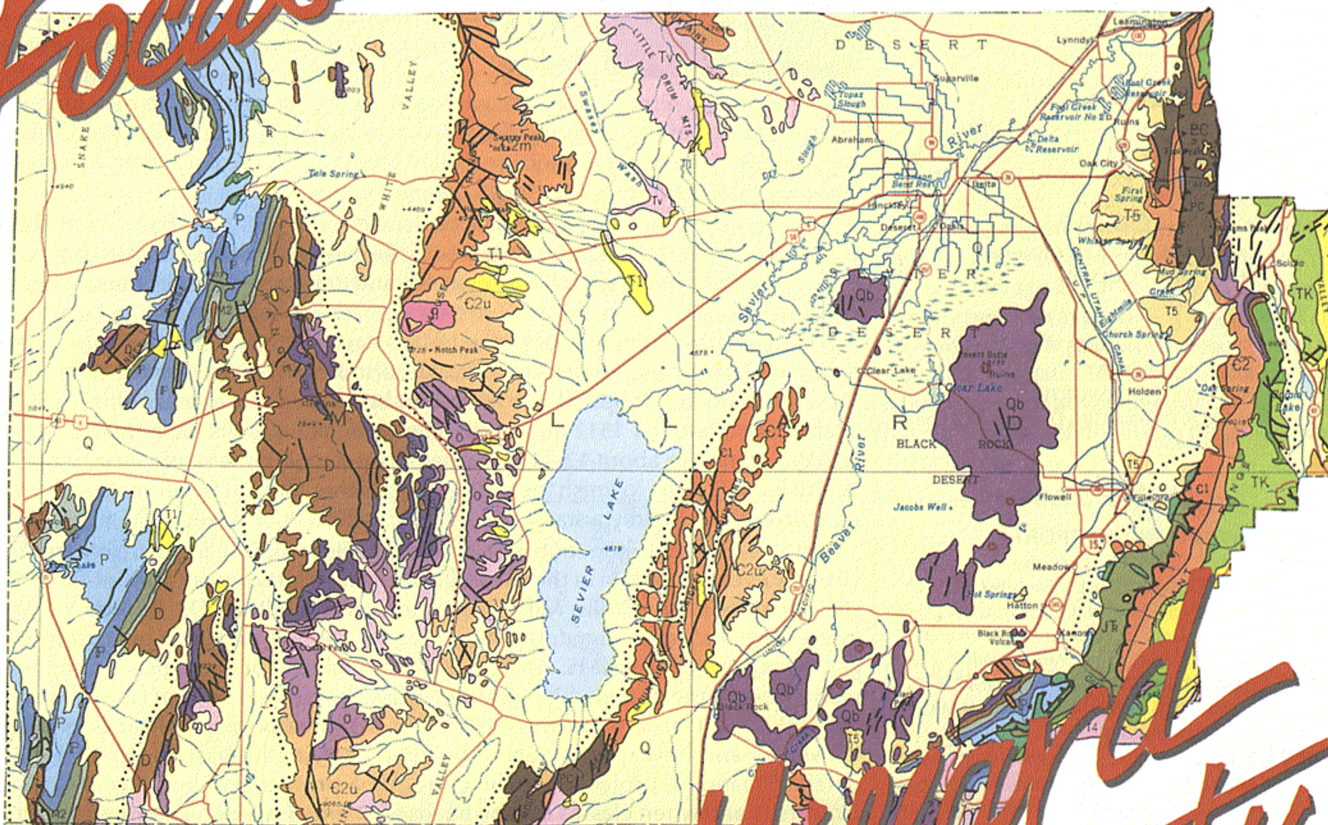
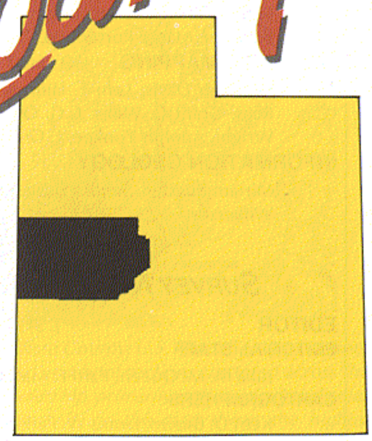
Focus on Millard County





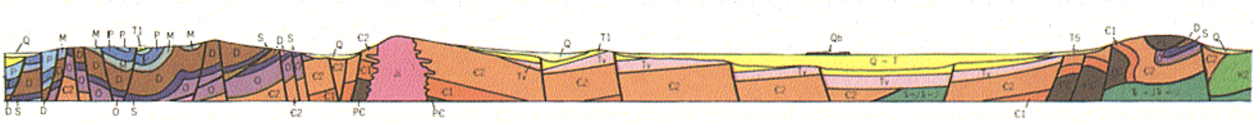
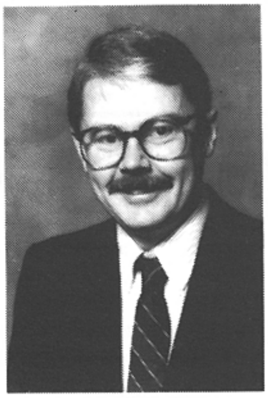


TABLE OF CONTENTS



THE DIRECTOR'S PERSPECTIVE *by M. Lee Allison*

Geological mapping of Utah has been going on for over 100 years and the resultant maps are largely responsible for development of the energy and mineral industries that play a principal role in the state's economy. Prospectors and wildcatters alike pour over each new map, deriving interpretations of the geology that may have eluded previous explorers. As the best and biggest targets are mined or drilled, the search turns to ever more subtle or complex ones, requiring ever more detailed maps.

Increasingly, these maps are also addressing the geologic hazards that threaten Utah. Earthquakes, landslides, expansive soils and many other dangerous conditions must be considered as population expands and development becomes more complex and widespread.

To address these critical needs the UGMS has embarked on a long-term program of detailed geologic mapping (1:24,000 scale, also known as 7-½ minute quadrangles) of the state. The vast scope of this effort can be seen in the number of maps required. Utah is comprised of 1512 quadrangles, of which about 300 have been mapped thus far. We complete about 12-15 maps per year, meaning that at the present rate it will take at least 75 years to finish the entire state. Other maps at larger scales are underway concurrently, primarily a statewide set of 1:100,000 county geologic maps.

The UGMS Mapping Section is headed by Dr. Hellmut Doelling who has trekked over virtually every mountain in the state during the last thirty years. The full-time mapping staff includes Grant Willis, Mike Ross, and a new addition, Dr. Adolph Yonkee. It is interesting that approximately 100 geologists applied for the most recent mapping geologist position at UGMS. This once traditional role for geologists is disappearing in many areas of the country. In addition, UGMS has the services of Dr. Lehi Hintze and Dr. Jack Oviatt on a part-time basis. Lehi is professor emeritus at Brigham Young University and now spends 50% of his time applying his vast knowledge of Utah to detailed mapping projects. Jack is currently a professor of geology at Kansas State University and when classes end he heads west and devotes his summer to unraveling the Quaternary geology of Utah.

UGMS supports mapping projects by the U.S. Geological Survey, professors, independent geologists, and geology graduate students, to get the most comprehensive approach possible and to maximize our limited budget. As many as 60 different projects are underway at a given time, supervised or monitored by UGMS personnel.

The UGMS maps routinely receive outstanding praise for both geologic content and their superb production quality. Jim Stringfellow, who heads the Editorial Section, deserves strong credit along with staff cartographers Kent Brown, Pat Speranza, and Jim Parker for their beautiful and accurate work.

The UGMS mapping effort ranks as one of the premier such programs in the nation. Strong support by the state legislature for geologic mapping reflects a commitment to the long-term economic development and safety of the state. UGMS is equally commited to generating the best possible maps in a timely and cost efficient manner.

Survey Notes *is published quarterly by* **Utah Geological and Mineral Survey,** *606 Black Hawk Way, Salt Lake City, Utah 84108 (801) 581-6831. The UGMS inventories the geologic resources of the state, identifies its geologic hazards, disseminates information concerning Utah's geology, and advises policymakers on geologic issues. The UGMS is a division of the Department of Natural Resources. Single copies of Survey Notes are distributed free of charge to residents within the United States and Canada. Reproduction is encouraged with recognition of source.*

Focus On
Millard County

Lehi F. Hintze and Fitzhugh D. Davis

Millard County is in the process of becoming the subject of one of the Utah Geological and Mineral Survey's most widely used products — a county geological bulletin. Eastern Iron County was the subject of the first county-scale report published by the Survey 40 years ago. This was followed by county reports on Emery, Salt Lake, Cache, Washington, Daggett, Uintah, Garfield, Sanpete, Piute, Box Elder, and, most recently, Kane. Although the earlier reports were reconnaissance in nature they were very helpful in enabling compilation of the first authoritative map of the geology of the entire state which was published in the early 1960s (see "contributors" this issue). This comprehensive map, published on a scale of one-quarter inch equals one mile, was especially valuable in evaluating which federal lands in Utah should be requested by the state in return for state lands taken over by the federal government for military and other purposes. The county geology bulletins are similarly useful for land evaluation and planning, as well as for assessing geologic hazards and environmental risks.

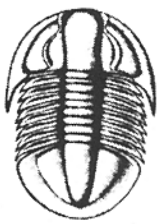
Accurate geologic maps depend on accurate topographic base maps. Utah is just recently completely covered by modern topographic quadrangle maps on the scale of 1:24,000, or 2000 feet to the inch. It takes about 1500 such quadrangle maps to cover Utah, and the state geological survey, with the encouragement of the state legislature, has embarked on a program of preparing up-to-date geologic maps for each of these quadrangles.

The county bulletin program, however, need not be delayed until the completion of all of the 1:24,000 quadrangle maps, for the county series is being prepared on a less detailed scale of 1:100,000, or 1 inch equals about 1.6 miles. The 1:100,000 topographic base maps are a new series being published by the U.S. Geological Survey. Coverage of all of Millard County at this scale has only recently become available. Thus the Millard County geologic map now in preparation by the UGMS will be published on the most up-to-date topographic base map available. The 1:100,000 maps are advantageous for planners and other users in that a great deal of detail can be shown on a conveniently sized map sheet.

__Figure 1.__ Geography of Millard County by M. K. Ridd. Fillmore and Delta are the largest towns; Fillmore is the county seat. Millard County is 4,254,000 acres large, or 6,648 square miles. Agriculture is the county's chief industry with production concentrated on alluvial slopes at the west base of the Pavant Range between Kanosh(K) and Holden(H), and on the floodplain flats of the Sevier River west of Delta. The western two-thirds of the county is virtually unpopulated because of limited water resources. The U.S. Bureau of Land Management (BLM) administers 71% of the land within Millard County; U.S. Forest Service oversees 8%; State of Utah owns 10% of the land as school sections scattered across the county; 11% of the land is in private ownership, primarily in the agricultural areas noted above. The dashed line marked -B- on the map shows the highest shoreline of Lake Bonneville, which covered half of the county 16,000 years ago. Sevier Lake is the modern remnant of Lake Bonneville which lowered rapidly about 12,000 years ago because of decreased rainfall and warmer climate.

Geologic maps of much of the bedrock exposed in the hills and mountains of Millard County have been prepared by various geologists for various reasons since the turn of the century. Graduate students at several universities, undergraduate students in geology field camps at Brigham Young University, petroleum geologists, mining geologists, federal government geologists — all have contributed to the understanding of Millard County's geology. The present effort by geologists with the state geological survey involves new mapping in areas of bedrock previously bypassed as well as a massive effort to map the surficial unconsolidated alluvial, eolian, and lacustrine deposits that cover the broad valley floors throughout the county, never heretofore mapped consistently. Geologists whose specialty is mapping Quaternary deposits have been working for the past four years to produce entirely new geologic mapping of the unconsolidated deposits that cover half the area of the county. Much of the mapping of Quaternary geology has been accomplished with the cooperation of the U.S. Geological Survey under their COGEOMAP program which was highlighted by Jack Oviatt and Fitz Davis in the Summer/Fall 1987 issue of Survey Notes.

Fossil collecting is very good in Millard County. Marine fossils can be collected from all of the geologic periods from Cambrian through Triassic time ...



Bedrock units in Millard County are shown on the map and cross section on the cover of this issue in various dark colors which contrast with the light yellow used for unconsolidated surficial rocks. Bedrock exposures are mostly in the mountain ranges which trend northerly to northeasterly as shown on the cover map and on figure 1.

Millard County includes a wide range of rock types and ages as can be seen on figure 2. The rocks, from Precambrian to Triassic age and shown in the lower two-thirds of figure 2, were originally laid down in nearly horizontal layers that accumulated on top of one another to form a layer cake nearly seven miles thick. These deposits were laid down on a shallow oceanic shelf, something like the coastal shelf of the present Atlantic or Gulf coasts. This shelf subsided as the sediments were deposited on it in somewhat the same way that a spring-loaded plate holder in a cafeteria goes down when you put a plate on it. Thus, although the stack of rocks in Millard County is very thick, most of the deposits were laid down in seas that were shallow enough to have sunlit waters where marine animals could flourish. Fossil collecting is very good in Millard County. Marine fossils can be collected from all of the geologic periods from Cambrian through Triassic time (shown in figure 2).

Cambrian and Ordovician strata in Millard County are especially noteworthy. Cambrian rocks in the House Range (see

MILLARD COUNTY ROCKS

AGE		MAP KEY	ROCK COLUMN	COMMENTS	FIG. NO.
Quaternary		Q		Lake Bonneville deposits	7,10,11
2 m.y. ago		Qb		Basalt flows and volcanoes	9
Tertiary	late	T5		Conglomerates on flank of Canyon Range and Church Hills	
	middle	T4		Volcanic and sedimentary deposits in Pavant Range	
		Tv		Volcanic rocks in Little Drum Mts. and near Cove Fort	
	early	Tl		Ancient lake deposits in Pavant Range above Richfield	
66 m.y. ago		TK		Conglomerates in Pavant Range	
Cretaceous		K		Older conglomerates in Pavant Ra.	
Jurassic		Ji		Notch Peak Granite	14
Triassic 245 m.y. ago		TR		Marine deposits in Pavant and Confusion Ranges	
Permian 290 m.y. ago		P		Marine limestone, dolomite, and gypsum in Confusion Range	
Pennsylvanian		IP		Coral and brachiopod-bearing limestone in Confusion Range	
Missis-sippian	Late	M2		Chainman Shale — oil-rich marine strata	
	Early	M1		Ridge-forming limestone	
Devonian 408 m.y. ago		D		Marine dolomite, limestone, and sandstone with corals, brachiopods and stromatoporoids	6
Silurian		S		Dark, banded dolomite in Confusion Range	6
Ordovician 505 m.y. ago		O		Black dolomite Orange quartzite Thin-bedded limestone and shale with abundant fossils near Ibex	5
Late Cambrian		Є2u		Cliff-forming limestone and dolomite at Notch Peak in House Range	14
Middle Cambrian		Є2m		Fossiliferous marine limestone and shale Trilobites Quick-lime quarry Gold mine	3,4 12 13
Early Cambrian 570 m.y. ago		Єl		Ancient beach-sand deposit that now forms pinkish-orange quartzite cliffs in House and Cricket Ranges	
Precambrian 1 billions years ago		pЄ		Quartzite, conglomerate, and slate in Canyon Range and northern San Francisco Mtns.	

Figure 2. *Rocks exposed in Millard County range in age from Precambrian strata about a billion years old to recent deposits of streams and dust-storms. Thickness of the layers of rock found in Millard County totals more than 42,000 feet, or 8 miles, a far greater thickness than that seen as you stand at the rim of the Grand Canyon. Millard County lay just below sea level until Triassic time, 245 million years ago. More recently volcanic eruptions have covered parts of the county with ash and lava.*

figures 2, 3, and 14) contain beds with trilobites and other fossils in them at many horizons within a sequence of limestones and shales more than a mile thick. There is no other section of Cambrian rocks in the world that has a more complete succession of Middle and Upper Cambrian fossils! The amateur collector, however, must be aware that most Cambrian rocks in the House Range are barren of fossils. They occur abundantly only in selected layers (see figure 3).

Ordovician strata in Millard County are also world-renowned. The geologic map on the front cover shows the location of a broad band of exposure of Ordovician strata, crossed by U.S. Highway 6-50 about 45 miles west of Delta. Figure 5 shows Fossil Mountain, the most famous Ordovician locality in the area. Most of the fossils in Ordovician rocks occur in an unusual rock type called intraformational conglomerate. It was deposited on broad tidal-flat areas along the Ordovician seashore, when the waves rolled back and forth across very broad, flat beaches. Accordingly, the fossils which are very abundant in these rocks are mostly broken into fragments by the paleowave action. For those patient enough to hunt through the fragmentary remains for reasonably complete specimens, the reward is in the variety of marine organisms that lived in this ancient sea. Representatives of virtually every animal phylum known to exist in Ordovician time can be found in these rocks in western Millard County. Scientists from all over the world have visited the Ibex area in the southern Confusion Range (see figure 5) to collect fossils found there and compare them with Ordovician fossils from other parts of the world. Fossils from the Ibex area have been described in a host of technical publications and serve as a comparative reference standard.

Fossils also occur in rocks of each geologic period between Ordovician and Triassic time as shown on figure 2. Corals, brachiopods, and crinoids (sea lilies) are the most common fossils found.

Three hundred and fifty million years of near steady-state marine deposition came to an end in Jurassic time when mountain building began in western Utah. The Jurassic granite near Notch Peak in the House Range (see figure 14) was the first evidence of impending disturbance, and by Cretaceous time the rocks of western Utah had risen above sea level several thousand feet and were being eroded to form Cretaceous sands and muds laid down in central and eastern Utah.

Following this mountain building event, western Utah never again fell below sea level. In mid-Tertiary time western Utah was the site of extensive volcanism. Millard County lies at the edge of three important mid-Tertiary volcanic centers: 1) between Beaver and Marysvale, 2) around the Tintic mining district, and 3) on the Utah-Nevada border west of Milford.

Late Tertiary time saw the development of the basin and range fault block topography that we see today in Millard County. All of the middle Tertiary and older rocks were broken into north-south basins and ranges by faults along which the valleys dropped and the ranges lifted. As the ranges went up they underwent erosion and the debris stripped off of the mountains filled the adjacent valleys, in some places to a thickness of as much as 15,000 feet.

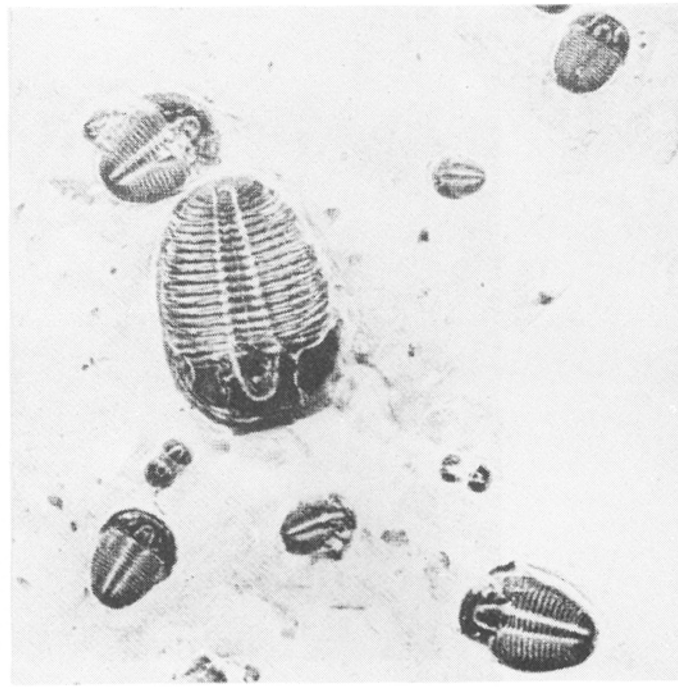


Figure 3. *Trilobites from Millard county are now one of the most widely distributed fossils in the world, on display in every museum and university fossil collection, foreign and domestic, as well as in most private fossil collections. The reason is not only their abundance, but also their unique preservation in a limited area in the Wheeler Amphitheater in the House Range. All of the trilobites above are* Elrathia kingi; *except for the two small agnostoid trilobites to the right and left front of the largest* Elrathia. *Fossils are shown at actual size.*

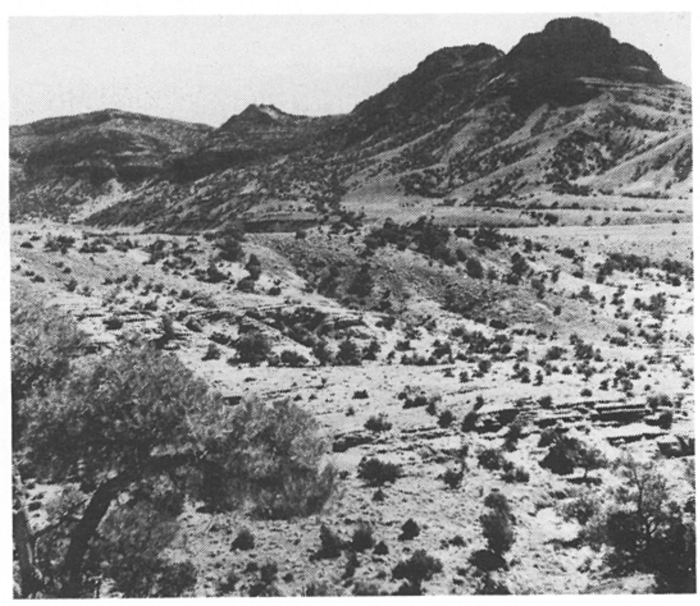


Figure 4. *Wheeler Amphitheater in the House Range is surrounded by thick-bedded ledges and cliffs of the Marjum Limestone. The bowl of the amphitheater is underlain by the less resistant Wheeler Shale whose thinner beds form the low outcrops in the lower half of the photo. Fossils occur throughout all layers of rock shown above but are mined commercially only from an especially fossiliferous layer about 2 feet thick. Rockhounds from all over come here to collect trilobites and are welcome, except in the commercially operated pits.*

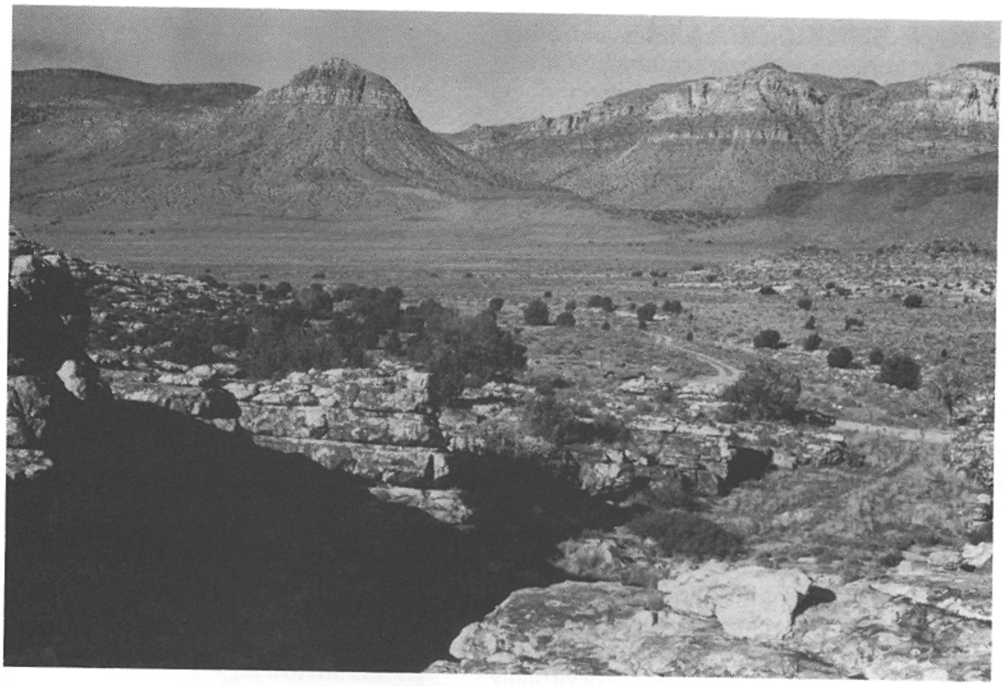


Figure 5. *Ibex, a now-abandoned ranch in the southern part of the Confusion Range, is a mecca for paleontologists who specialize in fossils of Early Ordovician age. Although most of the fossils are fragmentary, and hence not attractive to rockhound collectors, the variety of fossils of this age is greater here than any other known place in the world. Fossils that are found here serve as a worldwide reference standard to document the time of first appearance of certain organisms in the rock record. Animals that have been studied here include trilobites, brachiopods, conodonts, graptolites, gastropods, cephalopods, sponges, echinoderms, ostracods, bryozoans, pelecypods, and corals. Rocks in the foreground are ledges of Eureka Quartzite which also form the light-colored hilltops in the distance. Fossil Mountain is the hill in the left center distance. Fossil-bearing rocks are common on its flanks.*

Figure 6. *. U.S. Highway 6-50 winds westward up through Kings Canyon in the southern part of the Confusion Range. Dark rocks at base of hill in foreground are Silurian dolomites which are overlain by a light-colored dolomite of Devonian age. The dark Silurian dolomite can be seen again, out of its normal order, resting on top of the light-colored Devonian strata. The top stack of Silurian rocks were emplaced there by compressive forces about 100 million years ago when the west coast of the U.S. (which at that time was in central Nevada) was battered by islands riding on the Pacific Ocean plates. This compression raised a mountain chain in western Utah which shed erosional debris eastward to form the Cretaceous conglomerates now exposed in the Canyon and Pavant Ranges in eastern Millard County as shown on the cover map. King Top, the highland area at the left side of the photo, is currently under consideration as a Wilderness area.*

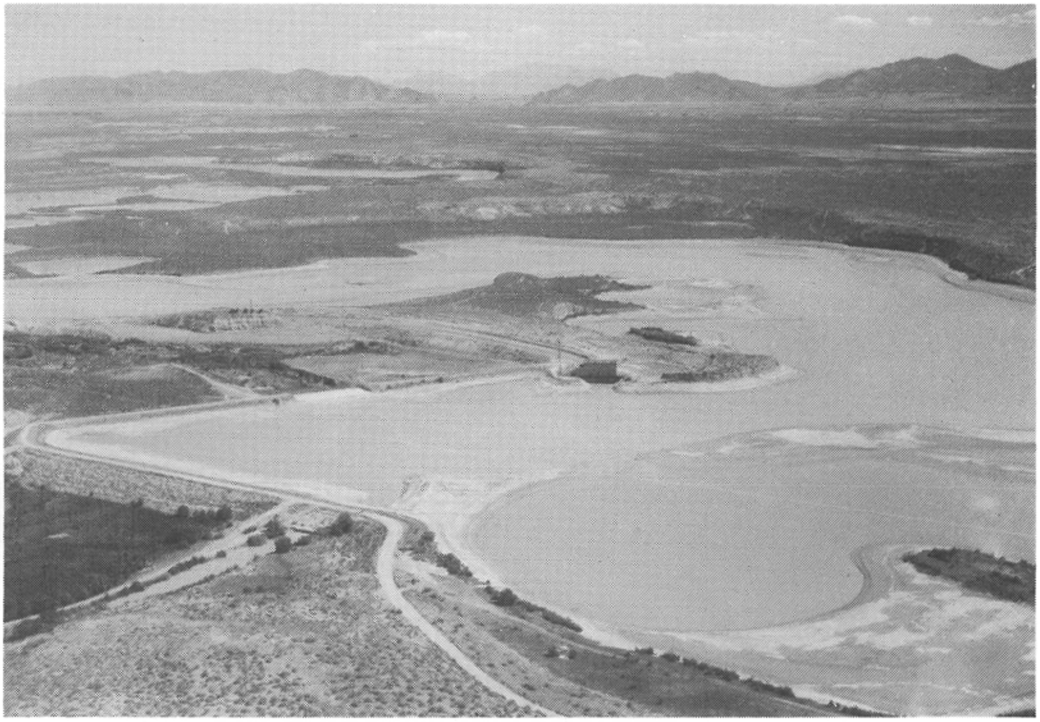


Figure 7. The flat-topped bench area between Delta and Leamington is made of silt and pea-gravel deposited as a delta in Lake Bonneville by the Sevier River several thousand years ago. When the climate changed and the level of Lake Bonneville dropped, the Sevier River cut a broad meandering channel through its own just-laid deltaic deposits. This is an aerial view of the DMAD Reservoir just northeast of Delta. It impounds water in the oxbows of the Sevier River floodplain for use in irrigation in the lands south and west of Delta. In June, 1983, after unusual precipitation runoff in its headwaters filled the Sevier River to overflowing, the DMAD dam broke and caused extensive flooding damage downstream on the outskirts of Delta and in the town of Deseret. Gilson Mountains can be seen in the left distance; Canyon Range is on the right hand skyline. Mount Nebo, near Nephi, can be seen through Leamington Canyon in the middle far distance.

The last episode of geologic history in Millard County involved two quite different geologic phenomena: the rise of Lake Bonneville and the eruption of young basaltic volcanic cones and lava flows (see figures 7 and 9). Some volcanic rocks that are useful or interesting are: cinder cones that furnish readily available road-building materials in places; snowflake obsidian near Black Rock that was used by Indians for arrowheads and is now sought by modern rockhounds; pumice from the same place that makes a light-weight building aggregate; sunstone, a feldspar mineral, that is found in a small volcanic outcrop at Sunstone Knoll along Utah State Highway 257, 9 miles south of Deseret.

ECONOMIC ASPECTS OF MILLARD COUNTY GEOLOGY

Although Millard County's economic well-being is mostly dependent on agriculture, mining has always played a role in the county. At present there are five productive mineral activities operating in the county: the Drum Mountains gold mine (see figure 13), the Cricket Mountain lime plant (see figure 12), the Sevier Lake salt recovery operation (see figure 11), the trilobite mine in the House Range operated by Delta residents (see figures 3 and 4), and last, but by no means least, the widespread production of sand and gravel for building and road construction. In addition certain products have seen past production and have potential for future production. These include pumice, obsidian, white marl, and tungsten.

Appraisal of additional mineral possibilities in the county is underway through a U.S. Geological Survey program called CUSMAP, an acronym for Conterminous United States Mineral Assessment Program (see the article by the same name in the Winter, 1986 issue of Survey Notes). Under CUSMAP the geological, geochemical, geophysical, computerized data-bank, and satellite imagery expertise of the U.S. Geological Survey is focused on large areas that have indications of metallic mineral resources. The entire area of Millard County is included in two CUSMAP study areas, the Richfield 2-degree quadrangle area and the Delta 2-degree quadrangle area now underway. The Utah Geological and Mineral Survey has participated vigorously in the CUSMAP program, the products of which are maps and other publications that are intended to help private industry's exploration programs to focus on target areas identified in the course of the CUSMAP effort. One of the areas in Millard County that may have potential for future gold production is located in the King Top area of the southern Confusion Range, an area that is also being considered as a Wilderness Preserve (see figure 6).

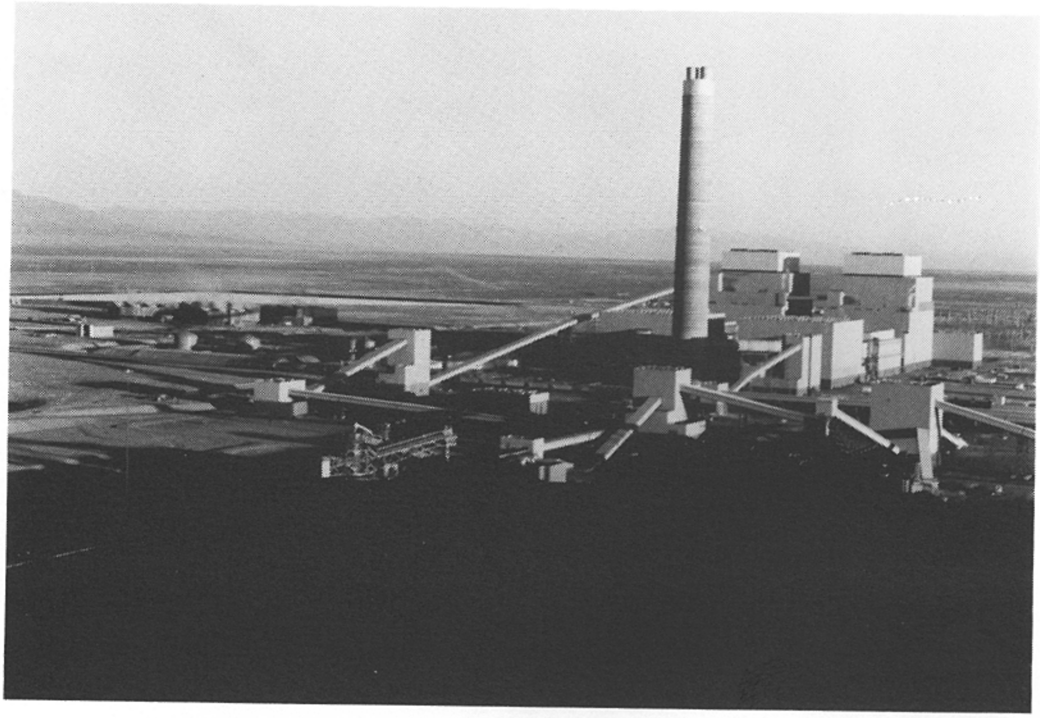


Figure 8. *Intermountain Power Project (IPP) north of Delta generates 1,600 MW of electric power, chiefly for use in southern California. Dark area in lower third of picture is a stockpile of Utah coal for the plant which uses about 4 million tons annually. Before any construction was started, a mile-long trench, about 14 feet deep, was dug across the planned site to check for recent fault breaks in the area. None were found, so construction began in 1981 and was completed in 1986 at a cost of about $4 billion. For cooling purposes the plant uses 18,500 acre feet per year of Sevier River water, obtained by buying water rights from agricultural users. The plant employs about 600 people. Although it is of modern design and uses low-sulfur coal, it nonetheless produces enough emissions to make a visible change in the aspect of the atmosphere over the Sevier Desert area.*

GROUND WATER

Ground water plays an important part in the agricultural economy of Millard County, especially in the Pavant Valley from Holden to Kanosh, in the Snake Valley near Gandy, Garrison and Eskdale, and in the springs at Black Rock. Water that is deposited as snow and rain on the high mountains that border Millard County on the east and west (the Pavant Range and the Snake Range, respectively) slowly percolates through the bedrock of the mountains, moving towards the fringing valley areas where it moves into unconsolidated alluvial materials of the valley fill. In all of these areas, understanding the characteristics of the valley-fill sediments near the land surface is of great importance. Ground-water conditions are monitored by the Water Resources Division of the U.S. Geological Survey and are apportioned by the State of Utah Water Rights Division. These federal and state agencies cooperate to ensure the best possible use of the limited ground-water resources of Millard County.

GEOLOGIC HAZARDS

There are two chief geologic hazards in Millard County: floods and earthquakes. Of the two, floods are by far the most frequent. Two somewhat different kinds of floods affect the county. Floods caused by summer cloudbursts affect local areas and cause local damage to roads and other works of man (see figure 10). Until the spring of 1983 the local cloudburst floods were the only kind anticipated. But 1983 was an unusually wet year, and water flowed toward the Sevier Lake in unexpected amounts from both major drainages, the Sevier River and the Beaver River. Large tracts of the desert south and west of Delta were flooded. Highway traffic on both U.S. Highway 6-50 west and Utah State Highway 257 south was shut off for several days. The DMAD dam broke (see figure 7) and the bridge over the Sevier River in the town of Deseret was washed out. The flood of 1983 set a new standard for road and bridge construction in the county.

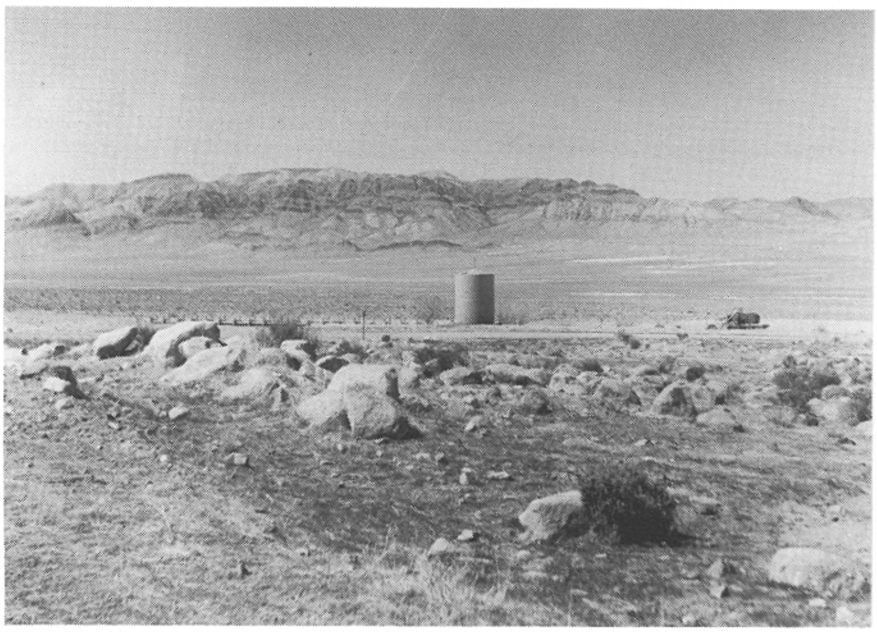
Earthquakes are less of a threat because they have occurred so rarely in Millard County. However, indication that they have occurred strongly in the past is documented by fault scarps found on the alluvial fans flanking the Canyon, House, and Drum Ranges. However there are very few tall buildings in Millard County and the normal home built under modern building standards would probably survive any likely earthquakes. The structures in greatest jeopardy would be old pioneer buildings with loose mortar or made of adobe bricks.

ACKNOWLEDGMENTS

Figure 1, showing the geography of Millard County, is modified slightly from the following map of Utah: Ridd, Merrill K., 1963, Landforms of Utah in proportional relief: Map supplement No. 3, Annals of the Association of American Geographers, v. 53, no. 4.

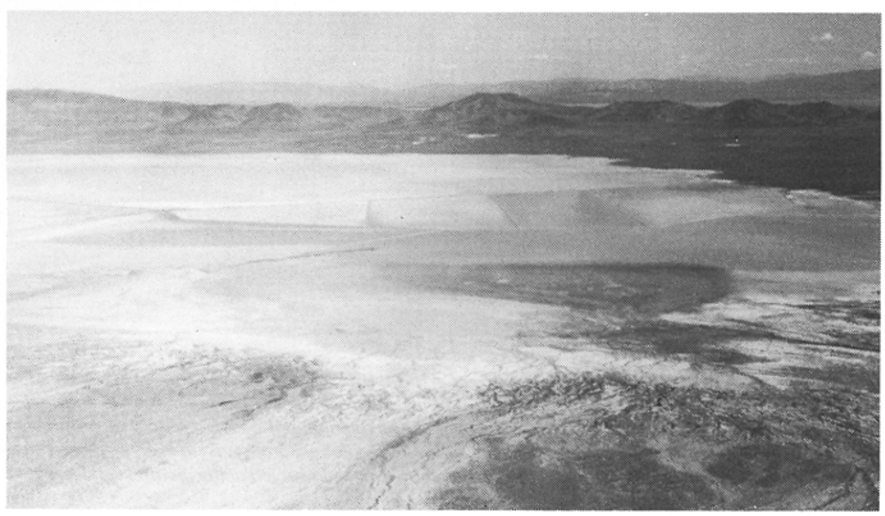
Colored map on front cover is from Utah Geological Highway Map, 1975, by Lehi F. Hintze, Brigham Young University Geology Studies, Special Publication 3.

Figure 9. *Aerial view of the Tabernacle eruptive center about 14 miles southwest of Fillmore. This name was used by G.K. Gilbert in his 1890 U.S. Geological Survey Monograph on Lake Bonneville because, when the highest ridge is viewed from the ground looking towards its north side (right side of this photo), it resembles the roof of the Salt Lake Tabernacle. Dr. Jack Oviatt, of Kansas State University, has dated the Tabernacle eruptions about 14,400 years before the present. The ragged dark area surrounding the smoother low circular hill is made of basalt flows that were erupted into Lake Bonneville, which covered the Sevier Desert floor at that time. The smooth hills are a cone of volcanic ash that was erupted into Lake Bonneville from the eruptive center which is the dark rocky area within the cone. Pavant Butte (known to most Millard County residents as Sugarloaf) is the volcano on the distant skyline.*



◁ ***Figure 10.*** *Watertank and sheep watering troughs below Painter Spring in the central House Range. Granite boulders in foreground are evidence of the power of floods produced by summer cloudbursts. The watertank lies a mile west of the mouth of the Painter Spring canyon. The boulders have been transported down the slope of the alluvial fan by rock-laden torrential debris flows sometimes described as being "too thick to drink and too thin to walk on." Major floods are separated by decades of milder runoff. The last major flood at Painter Spring occurred in July 1975. It not only ripped out the road and the water pipeline but also carried away most of the Painter Spring Campground, including cottonwood trees as much as 3 feet in diameter. White (Tule) Valley lies beyond the water tank. Mountains on skyline are part of the central Confusion Range.*

Figure 11. *South end of Sevier Lake showing collection trenches and diked evaporation ponds of the Crystal Peak Minerals company's salt recovery operation. Sevier Lake is the dead end for the Sevier River which heads near Bryce Canyon in southern Utah and winds northwards through central Utah before it cuts west through Leamington Canyon, passes by Delta and Deseret, and empties into the north end of Sevier Lake. The town of Delta was settled in 1905 after water rights to the Sevier River had been obtained to permit irrigation of the sunny, flat desert areas near the townsite. Irrigation at Delta and by upstream users spreads the available Sevier River waters so broadly that evaporation has virtually eliminated normal streamflows from ever reaching Sevier Lake since the early part of this century. However, an exceptionally wet year in 1983 caused a remarkable rejuvenation of Sevier Lake. Drier years since then have permitted the lake to evaporate away again.*



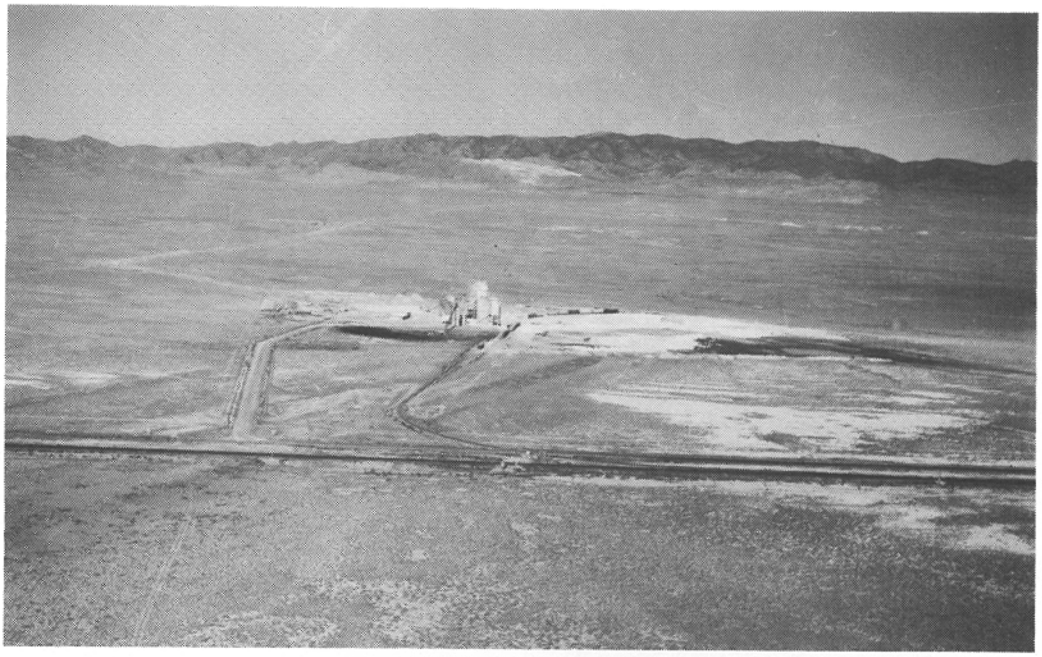


Figure 12. *Aerial view of Continental Lime Inc. Cricket Mountain plant, located about 35 miles south of Delta on Utah State Highway 257, which parallels the railroad in the foreground of the picture. The plant is capable of producing about 500 tons of high-calcium quicklime (CaO) per day by heating limestone ($CaCO_3$) to a temperature of 2,400 degrees Fahrenheit. Lime is used in wastewater treatment, as a flux in steel-making, in the manufacture of wood pulp and paper, in sugar refining, and in soil stabilization. Lime is second only to sulfuric acid, in tonnage used, as an industrial chemical in the United States. The limestone rock from which the quicklime is made is quarried from the Dome Limestone of Middle Cambrian age. The quarry is the light-colored area in the middle of the Cricket Mountains which form the skyline. The Dome Limestone is exceptionally pure calcium carbonate, containing only about 2 percent impurities, chiefly silica and magnesium. It was deposited about half a billion years ago when Utah was submerged under shallow seas.*

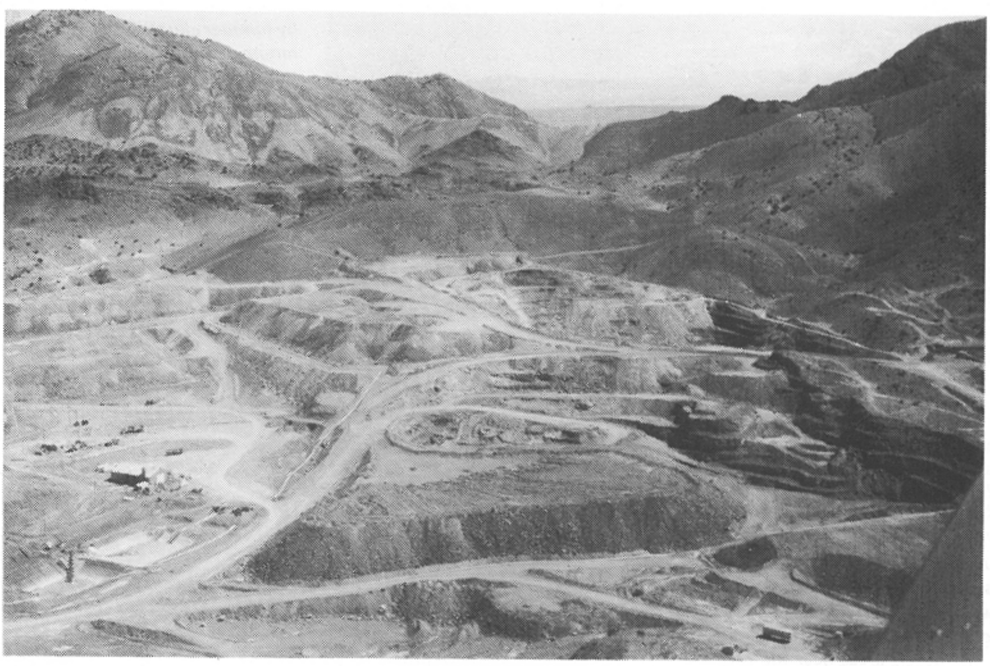


Figure 13. *Drum Mountains open-pit gold mine, formerly owned by Western States Minerals, now operated by Jumbo Mining (ASOMA) of Austin, Texas. Low-grade gold mineralization (0.04 ounces per ton) is disseminated in Middle Cambrian limestones and shales here. More than 120,000 ounces of gold, worth about 50 million dollars, have been produced from this mine since it was opened in the early 1980s. The profitable extraction of gold from low-grade ore was made possible by the development of the cyanide leach process, wherein cyanide solutions are sprinkled over ore placed on a waterproof collecting sheet. The cyanide dissolves gold out of the rock and carries it in solution to a collecting pond, shown in the lower left of the picture. Gold is recovered from the solution by a precipitation process carried out in the building near the collecting pond.*

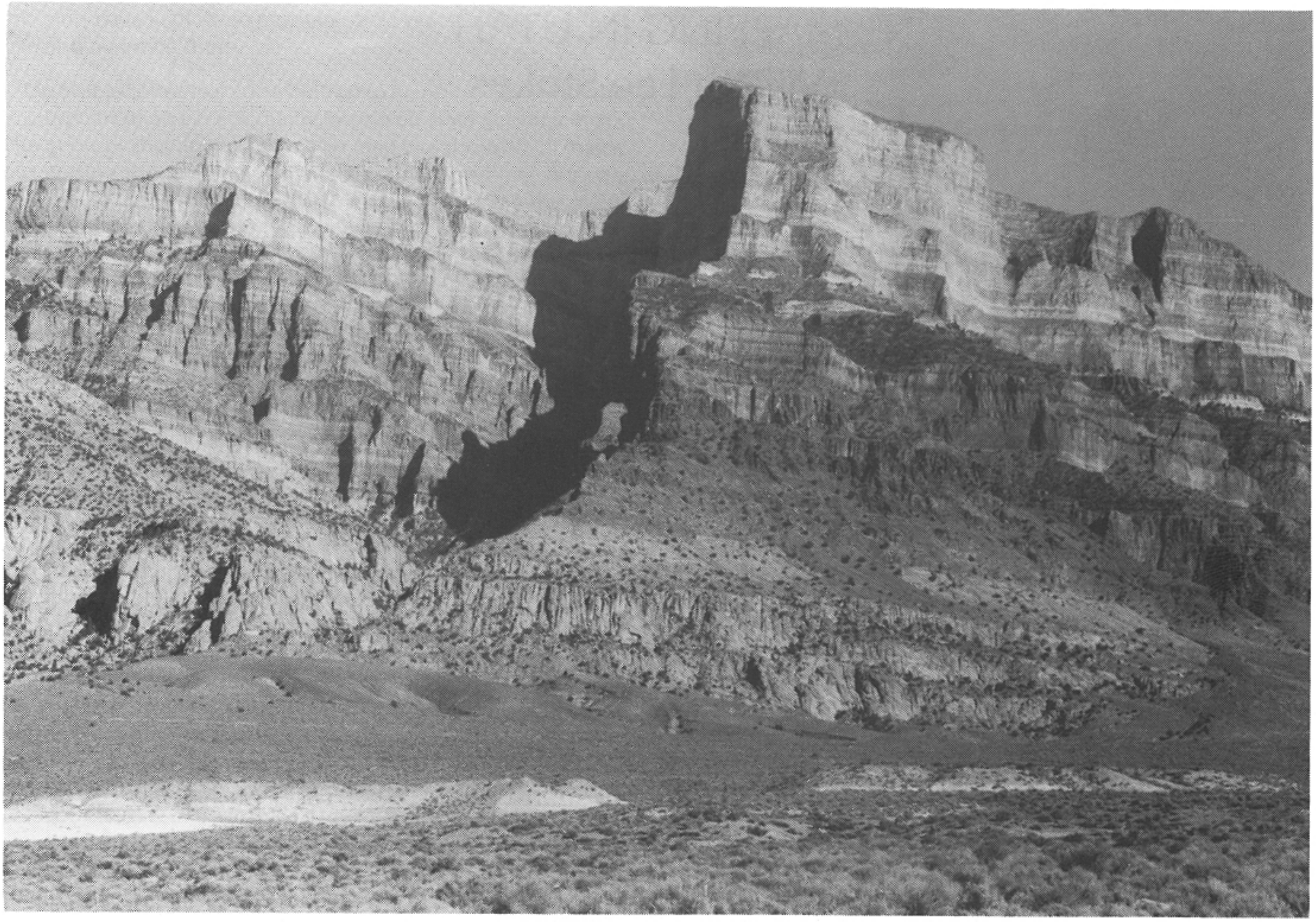


Figure 14. *Notch Peak, sometimes called Sawtooth, is not quite the highest peak in Millard County, but it is surely the most distinctive. At 9655 feet, its jagged profile, on the top of the House Range in the west-central part of the county, can be identified from most parts of the area. Its sheer north face (in shadow on the photo above) drops nearly vertically for 1500 feet, probably the highest free-fall in Utah. The top of Notch Peak is composed of the youngest Cambrian strata. Its base includes tabular igneous intrusions (sills) of Jurassic granite. Heat from the granite, which was emplaced at depth 170 million years ago, bleached some of the normally gray limestone beds to snowy white marble bands which can be seen part way down from the top. White beds in the foreground are marly clays that were deposited in Lake Bonneville when western Utah valleys were occupied by the Ice Age lake about 30,000 to 10,000 years ago.*

Staff Changes

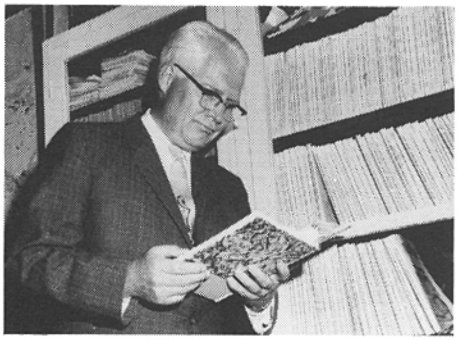
Dr. Adolph Yonkee of the University of Utah has accepted the position of Mapping Geologist with the Utah Geological and Mineral Survey. Dr. Yonkee most recently served as a research assistant at the University of Utah, and also served as research assistant at the University of Calgary. A graduate of the University of Wyoming with a B.S. and M.S. degree, he was the recipient of the Hill Foundation Scholarship.

Tom Chidsey, UGMS Petroleum Geologist, was recently promoted to Geologist 4. Congratulations and our best wishes to these ambitious fellows!

MEETINGS

American Institute of Professional Geologists will hold their annual meeting at Lake Tahoe, Nevada on September 27 to October 1, 1992. For details: AIPG, P.O. Box 665, Carson City, NV 89702, (702) 784-6691 — Jon Price.

Rapid Excavation and Tunneling Conference, a biennial event, will take place June 16-20, 1991 in Seattle, Washington. For details: SME Meetings Department, P.O. Box 625002, Littleton, CO 80162, (303) 973-9550.



Professor William Lee Stokes in his library at the University of Utah.

CONTRIBUTORS TO GEOLOGIC MAPPING IN UTAH
William Lee Stokes

by
Hellmut H. Doelling

The geologic mapping of a state requires much work and perseverance. Our knowledge of the geologic framework of Utah has been acquired through the efforts of many individuals, past and present. The UGMS recognizes the outstanding contributions of those who pioneered geologic mapping in Utah, have mapped significant areas of Utah, or have developed the foundation of geology in Utah. Each year the UGMS honors one of these contributors in *Survey Notes.* Last year the UGMS honored Charles Butler Hunt, who came to us from West Point, New York. This year we honor an individual who was born in Utah and whose contributions to geology are mainly centered in Utah.

William Lee Stokes, a foremost authority on the geology of Utah, is famous as a stratigrapher, educator, mapper, paleontologist, and uranium-vanadium economic geologist. He has been particularly effective in educating the public, especially through his geologic interpretations of the scenery of the Colorado Plateau. His valuable contributions have come through his many publications and textbooks. His positive influence, ideas, and thoughts have spilled over Utah's borders into the world through his students. Any effort to accurately number the nearly 150 publications he has written in his fruitful career would end in error; some certainly would be missed from the many national and local journals, guidebooks, newspaper articles, and survey publications in which his work has appeared. His list of publications represents 53 years of work, a list not yet ended.

William Lee Stokes, a foremost authority on the geology of Utah, is famous as a stratigrapher, educator, mapper, paleontologist, and uranium-vanadium economic geologist.

William Lee Stokes was born on 27 March 1915 in the coal-mining camp of Hiawatha in Carbon County, Utah. His family moved to Cleveland, in Emery County, when he was 3 years old and that is where he grew up. He started collecting rocks while helping on his father's ranch. Collecting rocks developed into an interest in geology, which he enrolled in when it was time to begin college. He started his schooling under Professor George H. Hansen at Brigham Young University and obtained his B.S. in 1937. That was also the year he wrote his first paper, co-authored by Hansen, *"Two Pleistocene musk oxen from Utah,"* published in the Utah Academy of Science Proceedings. He obtained his M.S. degree the following year from Brigham Young University with the thesis *"Stratigraphy and lithology of the Red Plateau, Emery County, Utah."*

In 1938 he began his doctoral work at Princeton University and completed it in 1941. He married Betty A. Curtis in 1939; she was the assistant geology librarian and he was a research assistant in vertebrate paleontology. While so working he returned to Utah and played a major role in the discovery of the Cleveland-Lloyd dinosaur quarry. His PhD. dissertation at Princeton was on the *"Stratigraphy of the Morrison Formation and related deposits in and adjacent to the Colorado Plateau."* The study was timely and he was hired by the U.S. Geological Survey from 1942 to 1947, mostly evaluating and studying vanadium and uranium deposits in the Morrison Formation. This work earned him a citation from the U.S. Department of the Interior for his wartime contributions. After embarking on his teaching career, Lee Stokes continued as a consultant with the Atomic Energy Commission, Standard Oil of California, and with other private and governmental organizations.

Talking about his field work, Lee recounts one hair-raising adventure on a boat trip down Cataract Canyon. There were about 6 huge rocks in the river and the boat managed to hit four of them and nearly capsized. He felt lucky to return alive. In another instance, he was climbing a cliff and as he came up over the ledge came eye to eye with a rattlesnake. Lee simply let go of the ledge and fell backward. He reasoned that the risk of the fall would be better than the risk of a snake bite on the face. Fortunately for all of us Lee suffered no serious damage.

Dr. Stokes began his teaching career at the University of Utah in 1947 where he remained until he retired in 1983. He supervised over 40 students in graduate studies, and founded the Earth Science Museum, forerunner of the present Utah Museum of Natural History. He headed the Geology Department for 13 years, and through his leadership the University significantly contributed to the geologic mapping of Utah. He attracted students from all over the west through the unique and valuable courses he created. Among these courses were his "Guidefossils of the Western Interior," "Regional Stratigraphy of the United States," and "Geology of Utah." He fostered and taught the skills that were necessary to write publishable articles by having his students turn in a journal for each class. The journals contained excerpts from recent literature, summarized class notes and reproductions of Dr.

Stokes' original chalkboard maps and drawings. Some of his students have kept these journals for 25 years or more, and still use and maintain them.

Dr. Stokes' principal contribution to mapping came with the production of an exceptionally improved state geologic map. The geology that appeared on this map was the work of many, but getting the funding, organizing and assembling the collections of maps to be compiled, and coordinating the many people to do the work fell to him. As Dr. Stokes explains, the Utah State Land Board consistently called for his advice about the value of various parcels of Utah-owned land during the 1950s. This began to take much of his time and he suggested that they fund a state geologic map. With this geologic map, the Land Board could evaluate much of the land on their own. Frank J. Allen, then Director of the Division of State Lands, liked the idea and asked Dr. Stokes what it would cost. Thinking about tying the geology to the Army Map Service 1:250,000 scale, 1° x 2° base maps, he estimated a minimum of $250,000. Most geologists with whom Dr. Stokes had discussed the proposal laughed, thinking it would cost much, much more. But he had a rough idea on how many unmapped holes remained in the state to insure uniform quality, and thought about recruiting local university professors and students to fill them.

Dr. Stokes also worried that the legislature would have a tough time accepting the $250,000 tab. Although his colleagues thought the sum was a bit small, legislators are generally very conservative about the way they spend taxpayers' money. But Allen was a good salesman, and the Utah legislature saw the great value of the project and approved it. Stokes collected maps from wherever he could get them; student theses, company files, old professional papers and bulletins, and private collections. He recruited several professors to help map the holes including Armand Eardley, Bronson Stringham and Max Erickson of the University of Utah, and Lehi F. Hintze of Brigham Young University. Lee received much help from his long-time chief assistant, James H. Madsen, Jr., who worked with him, before and after, collecting and assembling dinosaur bones. Several graduate students were steered into mapping huge parcels of previously unmapped territory as part of theses and dissertation requirements. Draftsmen reduced the map collection to the suitable scale, while Stokes and others made the decisions that reconciled the map boundary "faults." Williams & Heintz, map printers from Washington, D.C. got the printing contract and worked with Stokes to choose suitable colors and patterns. Before it was all over the new Utah geologic map became the most complex ever printed, using more patterns and colors than any previous geologic map had needed, according to Williams & Heintz. Five thousand copies of each quarter were printed. One batch of 5,000 were unacceptable because some of the map colors didn't match those on an adjacently printed quarter. Williams & Heintz graciously reprinted the entire run and allowed the state to keep the faulty ones. All were out of print in a little over 15 years. Lee's map of the Thompson uranium district was part of the final compilation and has been incorporated in all subsequent maps.

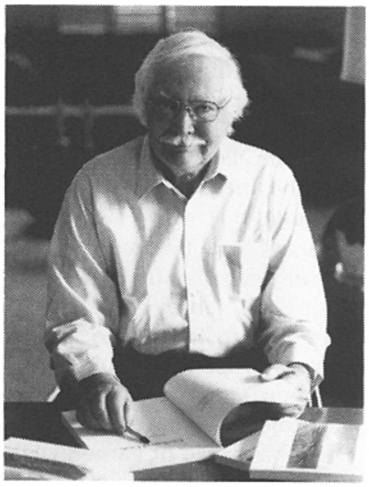
Before it was all over the new Utah geologic map became the most complex ever printed, using more patterns and colors than any previous geologic map had needed ...

The four quarters can still be seen today, spliced and glued together in wall displays at numerous locations. They still guide students of Utah geology toward the many geologic problems that remain to be solved. The Utah State Land Board's money was well spent, it would be difficult to estimate how much has been spent in Utah for exploration, studies, and geologic projects because of the map. It is certain that the use of this map has saved or earned Utahns and the State untold sums with respect to geologic hazards, natural resources, tourism, and land-use planning.

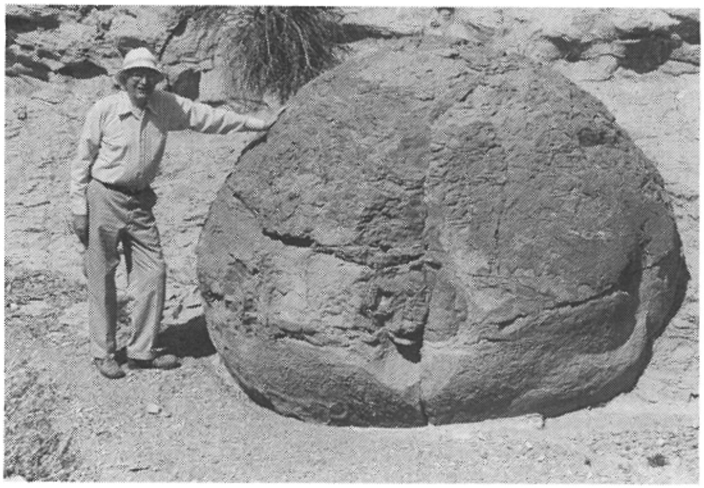
One of his more recent contributions has been the book, *"Geology of Utah."* Long on his list of things to do, this book represents the results of more than 20 years of teaching and fieldwork. The book covers the geology of the state period by period and explains why the "face of the land" is the way it is. The book is written in his own unique manner, easy to read, and in laymen's terms.

Dr. Stokes' influence on Utah geology continues. Geologic mappers are well aware of his contributions: the 13 formations and members and the several physical features he has named, and the stratigraphic problems he has solved. Numerous Utah geology societies have frequently called on Dr. Stokes to write guidebook articles, to be the guidebook editor, to speak on field trip stops, and to be a board member. For these activities the Utah Geological Association made him an honorary member in 1976 and also dedicated the 1982 annual guidebook to him. A summary of the honors he has received throughout the years are listed as follows: (1945) United States Department of the Interior, "War Service Certificate"; (1952) American Association for the Advancement of Science, elected Fellow; (1976) Utah Geological Association, Honorary Member; (1980) Best teacher awards for both the Department of Geology and Geophysics and the School of Mines; (1984) Rocky Mountain Section, Geological Society of America, presented in Durango, Colorado, "Outstanding service to all geologists in the Rocky Mountain Region"; (1985) Brigham Young University Achievement Award; (1987) American Men and Women of Science, Certificate of Achievement; (1989) Society of Economic Paleontologists and Mineralogists "Pioneer Award"; (1990) The Paleontological Society, "For Long Term Service Award."

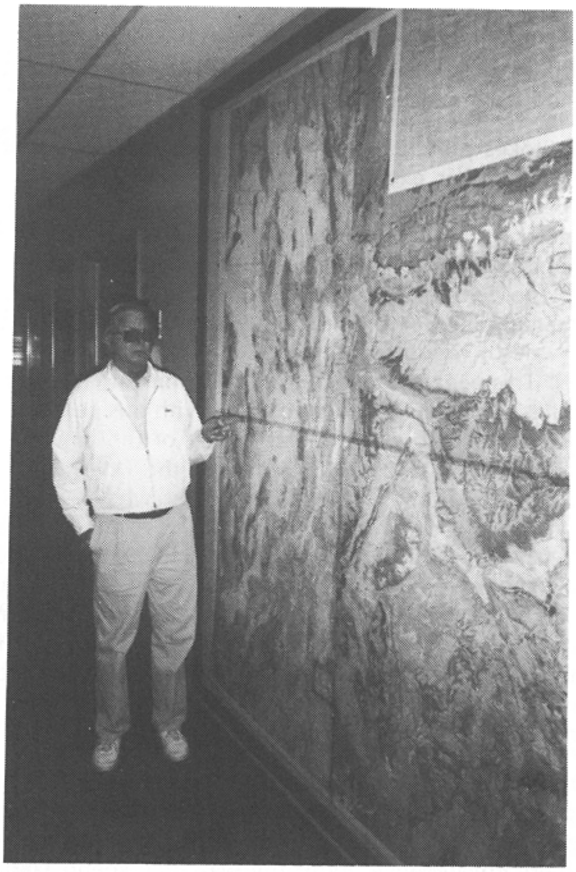
Students remember that in bygone days Lee's office was always a disarray of books, papers, maps, manuscripts, fossils, and rock specimens. His wife reports that his so-called den is kept the same way and is a constant battle for her, to keep the overflow from taking over the rest of the house. Whether in bygone days or in his house, he seems to know where everything is, despite the mess. One of his colleagues once said, "Lee's office is the most organized mess I ever saw!" Out of that organized mess has come the following list of what the UGMS feels are some of his more important literary contributions. We know that more are on the way.



Lee, autographing his book, "Geology of Utah," the result of more than 20 years of teaching and field work.



Dr. Stokes, preparing to collect a small specimen to take home to his den.



The four quarters of the 1:250,000 scale Utah geologic map, published in 1963, can still be seen today, spliced together in wall displays at numerous locations.

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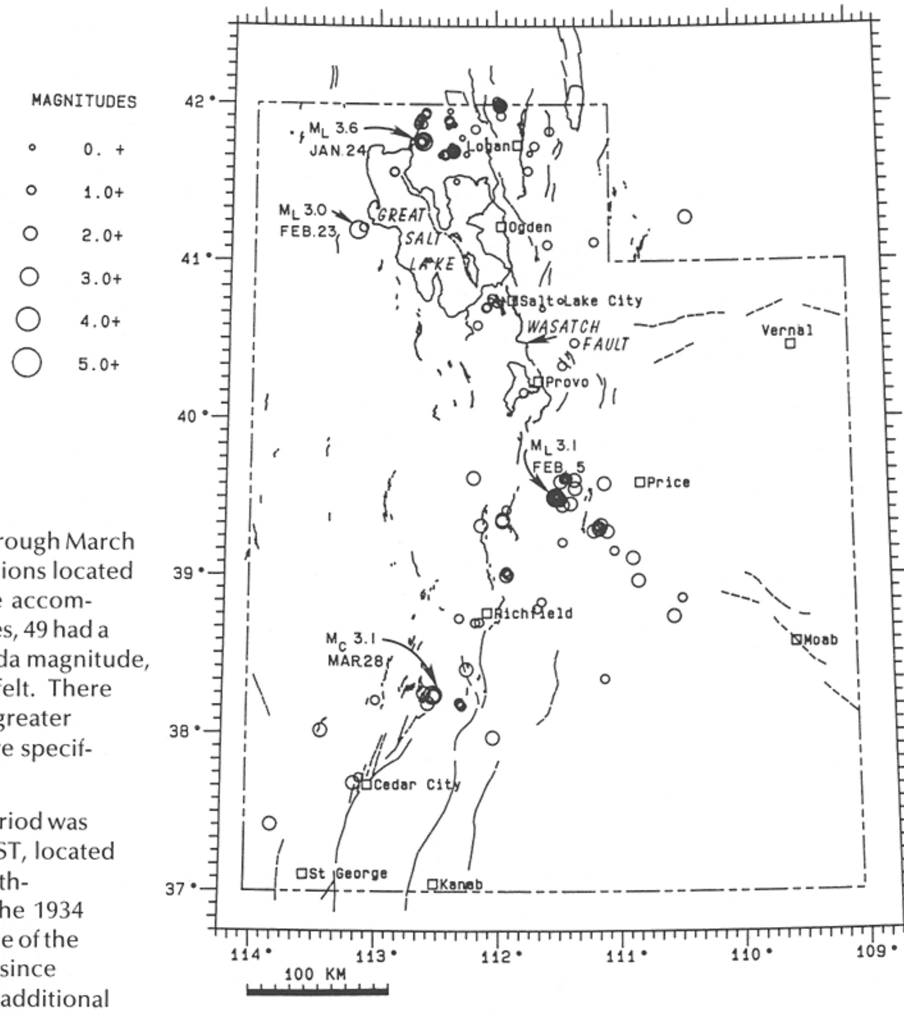
Earthquake Activity in the Utah Region

January 1 — March 31, 1990

by Susan J. Nava
University of Utah Seismograph Stations
Department of Geology and Geophysics
Salt Lake City, Utah 84112-1183
(801) 581-6274



During the three-month period January 1 through March 1990, the University of Utah Seismograph Stations located 170 earthquakes within the Utah region (see accompanying epicenter map). Of these earthquakes, 49 had a magnitude (either local magnitude, M_L, or coda magnitude, M_C) of 2.0 or greater, and one was reported felt. There were four earthquakes of magnitude 3.0 or greater during this report period. (Their epicenters are specifically labeled on the epicenter map).

The largest earthquake during the report period was a shock of M_L 3.6 on January 24 at 2:03 AM MST, located 26 km south-southeast of Snowville. This earthquake occurred in the same general area as the 1934 magnitude 6.6. Hansel Valley earthquake, one of the largest earthquakes that has occurred in Utah since settlement. During the report period, ten additional shocks occurred in the same general vicinity.

A cluster of 30 earthquakes occurred in the Sanpete Valley of central Utah from January 1-March 31. The largest event of the sequence was an M_L 3.1 earthquake that occurred on February 5 at 3:23 AM MST. This earthquake was reported felt in the towns of Moroni, Wales, and Mt. Pleasant. Two other earthquakes of magnitude 3.0 and greater occurred in the Utah region during the report period: an M_L 3.0 event on February 23 at 3:40 PM MST, located 20 km west of Lakeside; and an M_C 3.1 event on March 28 at 3:47 AM MST, located 14 km east-southeast of Beaver.

Seismic activity continued to occur in the Blue Springs Hills area of north-central Utah (see clustered epicenters 45 km west of Logan), the location of an M_L 4.8 earthquake on July 3, 1989. Eighteen earthquakes were located from January 1-March 31, in the area of the July 1989 Blue Springs Hills main shock. North-central Utah was also the site of an earthquake swarm located just south of the Utah-Idaho border, near the town of Cornish (see clustered epicenters 40 km northwest of Logan). During the report period, there were 32 locatable shocks associated with the Cornish swarm, ranging in magnitude from M_C 0.9 to M_L 2.3.

Additional information on earthquakes within the Utah region is available from the University of Utah Seismograph Stations.

Books & Papers

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Complete Bouguer gravity anomaly map of the Uinta and Piceance basins and vicinity, Utah and Colorado, by G.A. Abrams, V.J. Grauch and Viki Bankey. Prepared in cooperation with the Utah Geological and Mineral Survey and the Colorado Geological Survey, 1990. Scale 1:500,000. U.S.G.S. MF-2008-D.

Geologic map of the North Stansbury Mountains Wilderness Study Area. Tooele County, Utah, by M.P. Foose. 1989. Scale 1:24,000. U.S.G.S. MF-2061.

Preliminary surficial geological map of the Wasatch fault zone, eastern part of Utah Valley, Utah County and parts of Salt Lake and Juab counties, Utah, by M.N. Machette, 1989. Scale 1:50,000. (Accompanied by 30 page text). U.S.G.S. MF-2109.

Synfolding magnetization in the Jurassic Preuss Sandstone, Wyoming-Idaho-Utah thrust belt, by M.R. Hudson, R.L. Reynolds and N.S. Fishman *in* Journal of Geophysical Research, B, Solid Earth and Planets, v. 94, no. 10, 1989. p. 13,681-13,705.

GREAT SALT LAKE LEVEL

Date (1990)	Boat Harbor South Arm (in feet)	Saline North Arm (in feet)
Mar 01	4204.60	4203.50
Mar 15	4204.70	4203.50
Apr 01	4204.70	4203.50
Apr 15	4204.70	4203.40
May 01	4204.30	4203.40
May 05	4204.60	4203.30

Source: USGS provisional records.

New Publications from UGMS

Collapsible soil hazard map for the southern Wasatch Front, Utah, by R.L. Owens and K.M. Rollins, 38 p., 3 pl., 1:48,000, Miscellaneous Publication 90-1, 1990, ... $6.75

Utah Mineral Occurrence System Database for the Tooele 1° x 2° quadrangle, west-central Utah, by B.T. Tripp, M.A. Shubat, R.E. Blackett, and C.E. Bishop, Open-File Report 153DF, 1990, 1 diskette, ... $5.00

Geologic map of the Calico Peak quadrangle, Kane County, Utah, by H.H. Doelling and F.D. Davis, 16 p., 2 pl., 1:24,000, Map 123, 1989, ... $5.00

Geologic map of the Tule Valley, west-central Utah, by Dorothy Sack, 26 p., 1 pl., 1:100,000, Map 124, 1990, ... $5.00

Geologic map of the Elephant Butte quadrangle, Kane County, Utah and Mohave County, Arizona, by E.G. Sable and H.H. Doelling, 10 p., 2 pl., 1:24,000, Map 126, 1990, ... $5.00

Earthquake Hazards and Safety in Utah, 4 p., Public Information Series #6, 1990, ... Free

Geologic evaluation of wastewater disposal in bedrock, Duchesne County, Utah, by W.E. Mulvey and W.R. Lund, 20 p., 3 pl., scale 1:100,000, Special Studies 72, 1990, ...$6.75

Utah Indoor Radon Data, by D.A. Sprinkel and B.J. Solomon, Open-File Report 175-DF (diskette format), 1990, ... $5.00

Technical reports for 1988-1989, Applied Geology Program, RI 220, compiled by Bill D. Black, 159 p., 1990 . . . . $12.70.

Coal bed methane resource map, Castlegate A bed, Book Cliffs coal field, Utah, by A.C. Keith, J.S. Hand, and A.D. Smith, Open-File Report 176. 1 pl., 1:100,000, 1990 . . . . $3.00

Geologic map of the Latimer quadrangle, Iron County, Utah, by Lehi F. Hintze and Myron G. Best, Open-File Report 177, 9 p., 1 pl., 1:24,000, May 1990 . . . . $2.20

Geologic map of the Lund quadrangle, Iron County, Utah, by S. Kerry Fisher, Lehi F. Hintze, and Myron G. Best, Open-File Report 178, 9 p., 1 pl., 1:24.000, May 1990 . . . . $2.00

Cleat and joint system evaluation and coal characterization of the sub-3 seam coal, Castle Gate No. 3 mine, Carbon County, Utah, by Brigitte Hucka, S.N. Sommer, and A.C. Keith, 34 p., 1990; Open-File Report 170, ...$3.00

Cleat and joint system evaluation and coal characterization of the B-Bed coal, Dutch Creek Mine, Pitkin County, Colorado, by Brigitte Hucka, S.N. Sommer, and A.C. Keith, 36 p., 1990; Open-File Report 171, ... $3.00

Geologic map of the Patterson Pass quadrangle, Box Elder County, Utah, and Elko County, Nevada, by D.M. Miller, A.P. Lush, and J.D. Schneyer, 61 p., 2 pl., 1990, Open-File Report 172, ...$7.50

Geologic map of the Crater Island NW quadrangle, Box Elder County, Utah, by D.M. Miller, 50 p., 2 pl., 1990, Open-File Report 173, ... $6.50

Geologic map of the Richmond quadrangle, Cache County, Utah, by Jon Brummer and James McCalpin, 45 p., 2 pl., 1990 Open-File Report 174, ...$6.10

Provisional geologic map of Fisher Valley quadrangle, Grand County, Utah, by M.L. Goydas, 48 p., 3 pl., 1990 Open-File Report 167, ... $8.00

Geologic map of the Burns Knoll quadrangle, Beaver and Iron Counties, Utah, by Lehi F. Hintze, Myron G. Best, and Clark L. Weaver, Open-File Report 179, 10 p., 1 pl., 1:24,000, May 1990 . . . . $2.30

Geologic map of the Blue Mountain quadrangle, Beaver County, Utah, by Clark L. Weaver and Lehi F. Hintze, Open-File Report 180, 51 p., 2 pl., 1:24,000, May 1990 . . . . $7.10

Provisional geologic map of the Boulder Mountain quadrangle, Cache County, Utah, by Andrew R. Mork, Map 125, 9 p., 2 pl., 1:24,000, 1990 . . . . $5.00

Computer programs for paleostress reconstruction using fault slip data, by M.A. Shubat, 9 p., 1 360 K diskette; May 1990, Open-File Report 182-DF $5.00

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Geologic Projects in Utah 1990

by Michael Ross

During the 1980s, the UGMS included an annual "Geologic Projects in Utah" information request form with *Survey Notes* and infrequently published a computerized summary of responses for studies planned for the upcoming year. The summary has been useful for both UGMS and other geologists working in the state to make contact with colleagues working on similar or interrelated studies. However, the problem with the summary has been the inconsistency of its publication. Because the results were often not regularly published, the majority of geologists actively working in Utah did not respond. Beginning in 1990, the UGMS will publish a summary of the "Geologic Projects in Utah" on an annual basis. The information request form will be included in the Fall issue of *Survey Notes* and the summary of responses will be published in the next year's Spring issue of *Survey Notes*. This format will inform scientists planning summer field work in Utah and vicinity of the active studies scheduled for that year. We would appreciate receiving your reply as soon as possible. The summary of geologic projects will contain information on: 1) Investigator(s), 2) Organization(s), 3) County(ies), 4) Specific geographic or geologic area(s), 5) Type of study, 6) Title or topic of project, and 7) Scale of mapping (if relevant). Special searches can be made by investigator, county, type of study, and scale of mapping. We look forward to receiving your response for next year.

Explanation for **County** codes

County	Code
Beaver	BE
Box Elder	BX
Cache	CA
Carbon	CR
Daggett	DG
Davis	DA
Duchesne	DU
Emery	EM
Garfield	GA
Grand	GR
Iron	IR
Juab	JU
Kane	KA
Millard	MI
Morgan	MO
Piute	PI
Rich	RI
Salt Lake	SL
San Juan	SJ
Sanpete	SA
Sevier	SE
Summit	SU
Tooele	TO
Uintah	UI
Utah	UT
Wasatch	WS
Washington	WA
Wayne	WN
Weber	WE
Statewide	ZN

Explanation for **Type of Study** codes

Type of Study	Code
Economic Geology:	
a. General	EC
b. Coal	CG
c. Geothermal	GG
d. Minerals	MG
e. Petroleum	PG
f. Salines	SG
Engineering Geology	EG
Environmental Geology	EV
Geochemistry	GC
Geochronology	GR
Geologic Hazards	GH
Geologic Mapping	GM
Geophysics	GP
Hydrogeology	HG
Mineralogy	MN
Paleomagnetism	PM
Paleontology:	
a. Undifferentiated	PU
b. Invertebrate	PI
c. Vertebrate	PV
Palynology/Paleobotany	PY
Petrology	PT
Quaternary Geology	QG
Sedimentology	SD
Stratigraphy	SR
Structural Geology/Tectonics	ST
Volcanology	VO

GEOLOGIC PROJECTS IN UTAH

(UGMS) - Cooperative Funding

Investigator(s)	Organization(s)	County(s)	Location	Type of Study	Title / Topic	Scale of Map
Anderson, P.B.	Consult.(UGMS)	GR,EM,CR	Book Cliffs & Wasatch Plateau	PG,SR	Potential Strat Traps K Rxs Landward Pinchout	-0-
Bilbey, S.A.	UT Natural His	DU,UI	NE Utah/Split Mtn/Dinsr Qry Qd	SR,PV	Morrison Fm NE Ut; emphasis Stegosaur site	-0-
Bishop, C., and others	UGMS	JU,MI	Basin & Range, West-central Ut	EC	Mineral Occurences of the Delta 1X2 Sheet	250000
Blackett, B., and others	UGMS	BE,IR,PI	Southwestern Utah	MG	Mineral Resources of Richfield 1X2 Quadrangle	250000
Blackett, B., and others	UGMS	IR	NW of Pine Valley Mountains	GG,GM,GP	Geothermal Investigation of Newcastle, Utah	24000

Blackett, B., and others	UGMS	MI	Cove Fort - Sulphurdale area	GM,GG,MG	Geology of the Cove Fort - Sulphurdale Area	24000
Bruhn, R.	U of U (UGMS)	JU,SA,UT	Southern Wasatch Fault Zone	ST	Modeling Structure & Earthquake Characteristc	-0-
Brummer, J.	USU (UGMS)	CA	Cache Valley/Bear River Mtns	GM	Geology of the Richmond Quadrangle	24000
Bugden, M.	UGMS	WA	Southwestern Utah	EC	Economic Resources of Washington Co., Utah	-0-
Caputo, M.V.	Miss. St. Univ	EM,WW,KA	Colorado Plateau	SD,SR	Facies & Basin Evolution of Middle J Strata	-0-
Chan, M.A.	U of U (UGMS)	EM	Wasatch Pl/Castle V/San Raf Sw	SD,SR	Deltaic & Shelf Seqs K Blackhawk Fm/Mancos Sh	-0-
Chan, M.A.	Univ of Utah	WS	Wasatch Mtns/Big Cottonwood Ca	SD,SR,GM	Tidal Rhythmites in the Pc Cottonwood Fm	-0-
Chan, M.A.	Univ of Utah	GR,SJ,WW	CO Plat/Glen Canyon Natl Rec A	SD,SR	Paleosols & Eolian Depostion in P Organ Rx Fm	-0-
Chan, M.A.	Univ. of Utah	CR,EM	CO Plat/W side San Rafael Swel	SD,SR	Depositional Sequences in the K Emery Ss	-0-
Chapman, D.S., & Deming, D.	U of U (UGMS)	ZM	Statewide	PG,GC	Petroleum Source Rock Evaluation	-0-
Chidsey, T.	UGMS	MO,RI,SU	Overthrust Belt of Northern Ut	PG	Exploration UT Overthrust Belt in the 1980's	-0-
Chidsey, T.	UGMS	ZM	Statewide	PG,SR,GC	Precambrian Source Rock Potential	-0-
Chidsey, T., and others	UGMS & DOGM	ZM	Statewide	PG	Oil & Gas Fields of Utah	-0-
Chidsey, T., and others	UGMS & DOGM	ZM	Statewide	PG	1989 Summary of Drilling Activity in Utah	-0-
Chitwood, J.	KSU (UGMS)	GR	Colorado Plateau/Book Cliffs	GM	Geology of the Hatch Mesa Quadrangle	24000
Christenson, G.	UGMS	ZM	Statewide	GH,EG	Earthquake Hazards Map of Utah	750000
Christiansen, E.	BYU (UGMS)	TO	Sheeprock Mtns/Western Utah	MM,GC,PT	Mineral Chem of the Be/Y-rich Sheeprx Granite	-0-
Coogan, J.	Univ.Wy (UGMS)	RI	Black Mtn/Bear Lake Fault Area	GM	Geology of the Sheeppen Creek Quadrangle	24000
Coogan, J.	Univ.Wy (UGMS)	RI	Black Mtn/Bear Lake Fault Area	GM	Geology of the Bear Lake South Quadrangle	24000
Davis, F.D.	UGMS	MI	Western Utah/Great Basin	GM,QG,EG	Quaternary Deposits in Millard Co., Utah	100000
Davis, F.D.	UGMS	MI	Sevier Desert	GM,QG	Geology of the McCormick Quadrangle	24000
Doelling, H.H.	UGMS	GR	Eastern Utah/Colorado Plateau	GM	Geology of Southern Grand Co., Utah	100000
Doelling, H.H.	UGMS	GR	Arches Natl Park/ N Paradox Bs	GM	Geology of the Windows Quadrangle	24000
Doelling, H.H.	UGMS	GR	Arches Natl Park/N Paradox Bs	GM	Geology of the Mollie Hogans Quadrangle	24000
Doelling, H.H.	UGMS	GR	Arches Natl Park/N Paradox Bs	GM	Geology of the Klondyke Bluffs Quadrangle	24000
Doelling, H.H.	UGMS	GR	N Paradox Bs/Salt Anticline Ar	GM	Geology of the Fisher Towers Quadrangle	24000
Doelling, H.H.	UGMS	GR	Arches Natl Park/N Paradox Bs	GM	Geology of the Merrimac Butte Quadrangle	24000
Doelling, H.H., & Ross, M.L.	UGMS	GR	N Paradox Bs/Salt Anticline Ar	GM,ST,SR	Geology of the Big Bend Quadrangle	24000
Doelling, H.H., & Ross, M.L.	UGMS	GR	N Paradox Bs/Salt Anticline Ar	GM,ST,SR	Geology of the Moab Quadrangle	24000
Doelling, H.H., and others	UGMS	GR	Canyonlands/Colorado Plateau	GM	Geology of the Gold Bar Canyon Quadrangle	24000
Eldredge, S.	UGMS	GR	East-central Utah	EC	Economic Resources of Grand Co., Utah	-0-
Evans, J.P.	USU (UGMS)	CA	Cache Valley/Bear River Mtns	GM	Geology of the Logan Quadrangle	24000
Evans, J.P.	USU (UGMS)	CA,RI	Northern Utah/Bear Lake Area	ST,GP	Structural Setting of Seismicity in N Utah	-0-
Evans, J.P.	USU	BX,CA,RI	Northern Utah	GM,ST	Geologic Map of the Logan 30x60 sheet	100000
Felger, T.	UM-Duluth(UGMS)	JU	Juab Valley/W Gunnison Plateau	GM	Geology of the Skinner Peaks Quadrangle	24000
Fiesinger, D.W.	USU	BX	Northwestern Utah	SR,PT,GR	Tert.-Quat. Volcanism in Western Box Elder Co	-0-
Gloyn, R.W.	UGMS	MI	Drum Mountains of Western UT	MG,GM	Geology of the Drum Au Mine	600
Grant, S.K.	UM-Rolla (UGMS)	WA	Pine Valley Mountains	GM,PT	Geology of the New Harmony Quadrangle	24000

Hintze, L.F. & Davis, F.D.	UGMS	MI	Western Sevier Desert	GM	Geology of the Red Knolls Quadrangle	24000
Hintze, L.F., & Anderson, E.	UGMS & USGS	WA	SW Utah & SE Nevada	GM,ST,SR	Geology of the Dodge Spring Quadrangle	24000
Hintze, L.F., & Davis, F.D.	UGMS	MI	Western Utah/Great Basin	GM,EC,GH	Geology of Millard Co., Utah	100000
Hintze, L.F., & Davis, F.D.	UGMS	JU	Western Utah/Great Basin	GM,EC,GH	Geology of Juab Co., Utah	100000
Huffman, . . ., and others	USGS	GR,SJ,WN	Paradox Bs/Colorado Plateau	SD,SR,ST	Evolution of the Paradox Basin	-0-
Huffman, A.C., and others	USGS	GA,GR,SJ	SE Utah, SW Colorado	PG,SR,ST	Geologic Evolution of the Paradox Basin	-0-
Hunt, G.L.	C-P Minig(UGMS)	CR,EM,SA	Wasatch Plateau	ST	Thin-skinned Deformation Mechanisms of WP	-0-
Jackson, M., & Noller, J	USGS (UGMS)	GA	Southern Henry Mountains	GM	Geology of the Copper Cr. Benches Quadrangle	24000
Jensen, M.E.	UGMS/Dept.Healt	BX	Northern Wasatch Mountains	GM	Geology of the Brigham City Quadrangle	24000
Jensen, M.E.	UGMS/Dept.Healt	BX	Northern Wasatch Mountains	GM	Geology of the Bear River City Quadrangle	24000
Keith, J.D., & Witney, J.A.	Univ.Ga (UGMS)	JU,UT	East Tintic Mtns	GC,PT,MG	Characterization of Productive Intrusions in	-0-
Kowallis, B.J.	BYU	CR,EM,WN	Northwestern Colorado Plateau	GR,SD	Fisn Track Dating J Morrison/K Cedar Mtn Fms	-0-
Lessig, H.D.	Consult. (UGMS)	-0-	Wasatch Front/Wasatch Mtns	QG,EV	Pleistocene Soil Profiles along the Wasatch	-0-
Lowe, M.	UGMS	WS	North-Central Utah	GM,QG,GH	Surficial Geology of Wasatch Co., Utah	24000
Lowe, M.	UGMS	DA	Wasatch Mountains	GH,EG	Detailed Debris-flow Hazard Evaluations	-0-
Lutz, S.J.	UURI (UGMS)	CR,EM	Northern San Rafael Swell	PG,SD	Geology of the Grassy Trail Creek Oilfield	-0-
Marlatt, G.	Consult. (UGMS)	EM,GR	Colorado Plateau	MG	Au Anomalies in the Mancos Shale	-0-
Hammond, B.	BYU/NFS (UGMS)	WA	Beaver Dam Mountains	GM,ST	Geology of the Jarvis Peak Quadrangle	24000
Harty, K.M.	UGMS	TO	Tooele Valley	GH	Debris-flow Hazards of Tooele Valley	-0-
Harty, K.M.	UGMS	ZM	Statewide	GH	Utah Landslide Compilation Maps	100000
Hecker, S.	UGMS	DA	Antelope Island	GH,EG	Engineering Geology & Hazards - Antelope Is.	-0-
Hecker, S.	UGMS	ZM	Statewide	QG,GM,GH	Quaternary Tectonics of Utah	500000
Hecker, S.	UGMS	TO	Northern Oquirrh Mtns.	GH,ST,GM	Paleoseismic Study of N. Oquirrh Fault Zone	24000
Hintze, L.F.	UGMS	IR	Escalante Valley	GM	Geology of the Latimer Quadrangle	24000
Hintze, L.F.	UGMS	IR	Southern Wah Wah Mountains	GM	Geology of the Lund Quadrangle	24000
Hintze, L.F.	UGMS	MI	Little Drum Mountains	GM	Geology of the Smelter Knolls W Quadrangle	24000
Hintze, L.F.	UGMS	MI	Little Drum Mountains	GM	Geology of the Little Drum Pass Quadrangle	24000
Hintze, L.F.	UGMS	MI	Burbank Hills - Western Utah	GM	Geology of the Big Jensen Pass Quadrangle	24000
Hintze, L.F.	UGMS	MI	Burbank Hills - Western Utah	GM	Geology of the Burbank Pass Quadrangle	24000
Hintze, L.F.	UGMS	WA	SW Utah, NW of Beaver Dam Mtns	GM	Geology of the Motoqua Quadrangle	24000
Hintze, L.F.	UGMS	MI	Burbank Hills - Western Utah	GM	Geology of the Cedar Pass Quadrangle	24000
Hintze, L.F.	UGMS	WA	SW Utah & SE Nevada	GM	Geology of the Scarecrow Peak Quadrangle	24000
Hintze, L.F.	UGMS	BE,IR	Southern Wah Wah Mountains	GM	Geology of the Blue Mountain Quadrangle	24000
Hintze, L.F.	UGMS	BE,IR	Escalante Valley	GM	Geology of the Burns Knoll Quadrangle	24000
Hintze, L.F.	UGMS	WA	SW Utah, Beaver Dam Mountains	GM	Geology of the Castle Cliff Quadrangle	24000
Hintze, L.F.	UGMS	MI	Burbank Hills - Western Utah	GM	Geology of the Deadman Point Quadrangle	24000
Hintze, L.F.	UGMS	WA	SW Utah, Beaver Dam Mtns.	GM	Geology of the West Mountain Peak Quadrangle	24000
Hintze, L.F.	UGMS	WA	SW Utah, Beaver Dam Mountains	GM	Geology of the Shivwitz Quadrangle	24000

Hintze, L.F.	UGMS	WA	SW Utah, S of Bull Valley Mtns	GM	Geology of the Gunlock Quadrangle	24000
Hintze, L.F. & Davis, F.D.	UGMS	MI	Western Sevier Desert	GM	Geology of the Long Ridge Quadrangle	24000
Mattox, S.	NIU (UGMS)	PI,WM	CP/B&R Trans Zn; Awapa Plateau	GC,PT,SR	Geochemistry & Strat. Correlation T volc. rxs	100000
Mayo, A.L.	BYU (UGMS)	SL,WS	Wasatch Front/Salt Lake City	HG	Proposed Super Tunnel Groundwater Flow System	-0-
McDermott, J.G.	NIU (UGMS)	JU	San Pitch Mountains	GM	Geology of the Chriss Canyon Quadrangle	24000
Miller, D.M.	USGS (UGMS)	BX	Northern Pilot Range	GM	Geology of the Lucin Quadrangle	24000
Miller, D.M.	USGS (UGMS)	TO	B & R/Pilot Valley Playa	GM	Geology of the Silver Is. Pass Quadrangle	24000
Miller, D.M.	USGS (UGMS)	BX	Northern Promontory Mtns	GM	Geology of the Sunset Pass Quadrangle	24000
Miller, D.M.	USGS	BX,TO	Northwestern Utah, Bs & Rg	GM,ST	Tectonics NW Utah;Brigham Cty 2 sht compiltn	100000
Miller, D.M.	USGS (UGMS)	BX	Promontory Mountains	GM	Geology of the Golden Spike Mtn Quadrangle	24000
Miller, D.M.	USGS (UGMS)	TO	NW Utah/NE Nevada;S Pilot Mtns	GM	Geology of the Miners Canyon Quadrangle	24000
Miller, D.M.	USGS (UGMS)	TO	B & R/Silver Island Mountains	GM	Geology of the Graham Peak Quadrangle	24000
Mulvey, W.E.	UGMS	GR	Eastern UT/Colorado Plateau	GM,GH,QG	Quaternary Geology of Southern Grand Co., UT	100000
Mulvey, W.E.	UGMS	ZN	Statewide	QG,EG,GH	Problem Soil & Rock Deposits of Utah	750000
Nash, W.P.	U of U (UGMS)	ZN	Statewide	MG,MN	Yttrium Resources in Utah	-0-
Nelson, S.T., & Davidson, J.P.	UCLA	GA,GR,SJ	La Sal Mtns/Henry Mtns	GC,PT	Geochemistry & Isotope Geology of the	-0-
Nielson, R.L.	S.F.Austin Univ	Be,IR,MI	SW Utah; Basin & Range Prov	GM,PU,SR	Pluvial Lakes of Southwestern Utah	-0-
Nielson, R.L.	SFA Univ.(UGMS)	KA,WA	Southern Utah/Colorado Plateau	SD,SR	Depositional Analysis of P-Tr Rx Canyon Congl	-0-
Oaks, R.Q.	USU (UGMS)	CA,WE	Bear River Mtns/Northern Utah	SR,ST	Wasatch Fm paleovalleys & coeval N-S Faulting	-0-
Olig, S.S.	UGMS	ZN	Statewide	EG,GH	Utah's Ground Shaking Hazard from Earthquakes	-0-
Olig, S.S., and others	UGMS	ZN	S Intermountain Seismic Belt	EG	Probabilistic Ground-shaking Maps for SIMSB	-0-
Oviatt, C.G.	KSU/UGMS	MI	B&R Trans Zone/W of Valley Mts	GM,QG	Quaternary Geology of Scipio Valley	24000
Oviatt, C.G., & Sack, D.	KSU/UGMS & UW-M	JU,MI,TO	Northern Sevier Desert/G Basin	GM,QG	Quaternary Geology of the N Sevier Desert	50000
Paull, K., & Paull, R.A.	U.Wis,-Milw.	ZN	Colorado Plateau/Great Basin	SR,PV	Regional L Tr Conodont Biostratigraphy	-0-
Pechmann, J.C., and others	U of U (UGMS)	-0-	-0-	GP	Seismological Analysis of 4 Recent Earthquake	-0-
Peterson, D.	BYU (UGMS)	SA	Valley Mtns/CP-B&R Trans Zone	GM	Geology of the Hayes Canyon Quadrangle	24000
Price, D.	U of U (UGMS)	BE	Southern Mineral Mountains	GM,ST	Geology of the Cave Canyon Quadrangle	24000
Reid, J.E.	Consult. (UGMS)	ZN	Statewide	MG	Au Skarn Potential of Utah	-0-
Rollins, K.M.	BYU (UGMS)	IR	SW Utah/Cedar Valley/Cedar Cty	GH,QG	Collapsible Soil Map of the Cedar City Area	-0-
Ross, M.L.	UGMS	GR	Northern La Sal Mountains	GM,PT,GC	Geology of the Mount Waas Quadrangle	24000
Ross, M.L.	UGMS	GR	Northern La Sal Mountains	GM,PT,GC	Geology of the Warner Lake Quadrangle	24000
Ross, M.L., & Doelling, H.H.	UGMS	GR	N Paradox Bs/Salt Anticline Ar	GM,SR,ST	Geology of the Rill Creek Quadrangle	24000
Roth, P.H.	Univ. of Utah	CR,EM,GR	Colorado Plateau/Book Cliffs	PI,SR	Calcareous Nannofossils in the K Mancos Sh	-0-
Sable, E.	USGS	KA,WA	S Utah/Colorado Pl & Trans Zn	GM	Geology of the Kanab 30x60 Quadrangle	100000
Sable, E.	USGS	GA,IR,KA	S Utah/Colorado Pl & Trans Zn	GM	Geology of the Panguitch 30x60 Quadrangle	100000
Sable, E., & Doelling, H.H.	USGS & UGMS	KA	SW Utah/South of Kolob Plateau	GM	Geology of the Barracks Quadrangle	24000
Scott, R.B., and others	USGS & others	IR,KA,WA	SW Utah & SE Nevada	ST,SR,GC	Geology of Bs & Rg/Colorado Plateau Trans. Zn	100000
Shubat, M.A.	UGMS	JU	West Tintic Mountains	GM,MG	Geology of the West Tintic Mountains	24000

Shubat, M.A.	UGMS	JU	Keg Mountains/Slow Elk Hills	GM,MG	Geology of the Keg Mountains, Utah	24000
Smith, R.	U of U (UGMS)	DA,SL,UT	Wasatch Front Region	ST,GP	Geom. & Kinematics of Normal Faults - WFR	-0-
Solomon, B.J.	UGMS	SL,UT	Wasatch Front, SLC/Provo Areas	GM,EV,GH	Geologic Influence on the Indoor Radon Haz.	24000
Solomon, B.J.	UGMS	TO	West Desert & Tooele Valley	GM,EV,QG	Q Geology of WD/TV Hazardous Industrial Area	24000
Sorensen, M.L.	USGS (UGMS)	JU,UT	Southern Wasatch Mtns	GM,ST,MG	Geology & Ore Deposits, Mt Nebo/Santaquin Dis	24000
Sprinkel, D.A.	UGMS	JU,SA,UT	CP/B&R Trans Zone/Wasatch Mtns	SR	Stratigraphy of J Twin Cr. Ls & Arapien Sh	-0-
Sprinkel, D.A., & Bugden, M.G.	UGMS	WA	SW Utah, NE of Beaver Dam Mtns	GM,SR	Geology of Snow Canyon State Park	12000
Sprinkel, D.A., & Weiss, M.P.	UGMS & NIU	SA	Wasatch Plateau	GM	Geolgy of the Danish Knoll Quadrangle	24000
Sprinkel, D.A., & Weiss, M.P.	UGMS & NIU	SA	Sanpete Valley/Wasatch Plateau	GM	Geology of the Ephraim Quadrangle	24000
Sprinkel, D.A., and others	UGMS,NIU,USGS	SA	Sanpete Valley/S Gunnison Pl.	GM,SR,ST	Lithofacies & Structure of Christianburg Area	2400
Stoeser, D.B.	USGS	JU,MI,TO	West-central Utah/Bs & Rg	GM,EC,ST	CUSMAP Mineral Appraisal Delta 1x2 sheet	250000
Stokes, W.L.	U of U (UGMS)	SJ	Colorado Plateau/4 Corners Ar	SR	Correlation of Jurassic Sandstone Fms.	-0-
Stokes, W.L.	U of U (UGMS)	EM,GR,SJ	Colorado Plateau/Eastern Utah	SD,SR	Petrified Mini-forests in the Navajo Ss	-0-
Taylor, W.J.	U of U (UGMS)	GA,IR,KA	S High Plateaus/SW Utah	SD,SR	Basin Analysis of the Claron Fm	-0-
Thompson, A.B.J.	Consult. (UGMS)	BE,IR	Southwestern Utah	MG,GC	Acid-Sulfate Alteration Marysvale-Pioche Belt	-0-
Tilton, T.	U of U (UGMS)	KA	South of Paunsaugunt Plateau	GM	Geology of the Podunk Creek Quadrangle	24000
Tilton, T.	U of U (UGMS)	KA	Southern Paunsaugunt Plateau	GM	Geology of the Alton Quadrangle	24000
Trexler, J.H., & Goldstrand, P.	UN-Reno (UGMS)	GA,KA,WA	Southwestern Utah	SD,SR	Strat. & Sedmtolgy of the basal Claron Fm.	-0-
Tripp, B.	UGMS	ZN	Statewide	MG	High-Ca Limestone Occurences of Utah	-0-
Tripp, C.N.	Consult. (UGMS)	EM,SA,SE	Wasatch Plateau	PG	Oil & Gas Field Studies, Wasatch Plateau	-0-
Weiss, M.P.	NIU (UGMS)	SA	Sanpete Valley/Central Utah	GM	Geology of the Sterling Quadrangle	24000
West, M.W.	Consult. (UGMS)	SU,UI,UT	Uinta & Wasatch Mtns/NE Utah	GH	Seismotectonic Evaluation of SU,UI,UT Cos.	-0-
Willis, G.C.	UGMS	SE	Pavant Range & Sevier Valley	GM	Geology of the Sigurd Quadrangle	24000
Willis, G.C.	UGMS	GR	Colorado Plat/Westwater Canyon	GM	Geology of the Agate Quadrangle	24000
Willis, G.C.	UGMS	SE	Pavant Range & Sevier Valley	GM	Geology of the Richfield Quadrangle	24000
Willis, G.C.	UGMS	GR	Colorado Plateau/Book Cliffs	GM	Geology of the Dry Canyon Quadrangle	24000
Willis, G.C.	UGMS	GR	Colorado Plateau/Roan Cliffs	GM	Geology of the PR Springs Quadrangle	24000
Willis, G.C.	UGMS	GR	Colorado Plateau/Book Cliffs	GM	Geology of the Harley Dome Quadrangle	24000
Wiltschko, D.V.	TX A&M Univ.	RI	UT/WY/ID Overthrust Belt	ST,HG	Fluid Migration within ID-WY-UT Overthrust Bt	-0-

Teacher's Corner

by Sandra N. Eldredge

Volunteer opportunities for teachers are being offered for the first time this year with the U.S. Geological Survey (USGS). Through the Volunteer/Teacher/ Intern Program, teachers can spend part of their summer doing volunteer work with USGS scientists. Project activities will be conducted at a variety of locations across the U.S. Some projects are in need of teachers in particular, including creating earth science educational materials. For more information, request a copy of *Geologic Division Volunteer/Intern/ Teacher Opportunities 1990,* by writing to Geologic Division Volunteer Coordinator, U.S. Geological Survey, 912 National Center, Reston, VA 22092.

Inservice classes offered this summer at the Utah Museum of Natural History (UMNH) include: "Earthquake Science and Safety," July 11, 12; "Geology of the Rocky Mountain Province," July 30-August 3, August 9, 10, 11; "Naturalist Weekend at Snowbird," August 4, 5 and August 18, 19; and "Vernal Adventure," August 7-11. Call Deedee O'Brien at UMNH (581-6927) for more information.

For teachers interested in taking students on field trips, you are encouraged to contact the Utah Geological and Mineral Survey Information Section for ideas and materials to assist you in your endeavors.

UTAH DEPARTMENT OF NATURAL RESOURCES
Utah Geological and Mineral Survey
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Salt Lake City, Utah 84108-1280

Address correction requested
Survey Notes

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